

Examination the pre-service physics teachers' cognitive structure about the concept of "torque"

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Abstract. In order to realize the exact learning, it is important to know that how the individuals learn and how they construct the knowledge in their minds. If the prior knowledge that existed already in the mind of the individuals overlaps with the newly learned knowledge so the exact learning takes place in the mind of the individuals. In this context, according to the constructivism, it can be said that the individuals constructed the new knowledge by linking the prior knowledge to the existing one in their minds. This study aims to investigate the cognitive structures of 32 pre-service physics teachers related to the concept of torque by using the qualitative research methods. The data collected through the word association test (WAT) and it was analyzed by using content analysis method. The cognitive structures of the pre-service physics students were determined by different categories at the end of the content analyses process.

Keywords: Cognitive structure, pre-service physics teachers, torque, word association test

1 Introduction

Cognition is an umbrella term containing such concepts as thinking, learning and recalling in its body. In other words, it is the general name given to all of these processes. Individuals' understanding or learning a concept is directly related with the development of their mental activities. Structure is a structure exhibiting the mutual relations of concepts recorded in the long-term memory. Development in individuals' cognitive structure in terms of concepts is a process beginning with recording information about the relevant concept in the long-term memory [1, 2]. Learning a concept should not be considered as learning only the name of the concept or only its definition. On the contrary, it should be considered as the ability to set up associations between the concept and other related concepts. That is to say, knowledge elements forming in individuals' mind are associated with structures arising in consequence of their later learning. This means that individuals

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set up close associations between their previous learning and what they acquire later. If the association is set up correctly, meaningful learning can occur to a great extent. To put it in other words, if correct connections are set up between the newly learnt knowledge and previous knowledge, cognitive structure related with the learnt concept is formed [3]. Thus, when the above mentioned activity happens, meaningful learning occurs [4]. A number of studies have been conducted by using word association tests in science education [5, 6, 7, 8, 9, 10, 11 and 12]. When considered in this context, word association test is a very effective method in uncovering students' cognitive structures and in teaching concepts.

Within the scope of the study, pre-service physics teachers' conceptual framework about the concept of "torque" was examined by using the word association test, and the following research questions were tried to be answered:

1. How is the cognitive structure of the pre-service physics teachers in relation to the concept of "torque"?
2. How do the pre-service physics teachers configure the concept of "torque" in their mind?

2 Method

The current study was designed according to the qualitative research methods and it was conducted with pre-service physics teachers during the 2016-2017 academic year. The word association test (WAT) was used as a data collection tool and the collected data were analyzed by using the content analysis method.

2.1 Participants

This study was performed so as to determine 32 pre-service physics teachers' cognitive structures about the concept of torque. All of the participants were the third and fourth year students who had taken and passed Mechanics I course. They were in the 20-22 age range and took part in the research on the basis of volunteering.

2.2 Data collection tool

Word association test was used in the research as the tool of data collection. In addition, the drawings made by students related to the concept of "torque" have been used to identify the conceptual framework of the participants. Prior to the application, the participants were informed of word association tests. They were given a key concept and were asked to write the words coming into their mind related with the key concept in 40 seconds. The participants were also allowed 20 seconds to write sentences about the key concept. The key words were written repeatedly one under another as a list. The reason for this was to minimize the likelihood of chain answers and to prevent the students' previous word from influencing their next word. Even though writing the key word only once makes everything easier, it is also possible that participants can get away from the key word with each word they write [9].

2.3 Data analysis

The data collected through word association test were analyzed in this study by using the number of words, the number of answers and semantic relations technique. The data having semantic connections were grouped under the same category. Besides, the words which seemed not to be related, having nothing to do with the key word and used only once were removed from analyses. The initial results of the analysis were discussed with other physics education researcher and the inter coder reliability coefficient was archived to be 0.86.

After discussing the incompatibility between the researchers, the full agreement was reached finally. At the end of the study, pre-service physics teachers' cognitive structure in relation to the concept of torque was exhibited. Discussions as to the accuracy of the concepts pre-service physics teachers associated torque with and of their examples for torque were also offered in this study. The extent to which pre-service physics teachers' associations were scientific was also discussed in the study.

3 Findings

The findings obtained are presented on the basis of the analysis results of Word association test and students' drawings. The concepts determined through Word association test were primarily divided into categories by sequencing them according to their similarities and differences. After data collection by means of WAT, the findings were divided into four categories by taking semantic proximity into consideration. Table 1 shows the words and the categories the words are divided into. As is clear from Table 1, the categories are labelled as "Torque definition", "Torque – Lesson Relationship", "Direction of Torque", and "Torque in Daily Life". In addition to that, the words in each category are also listed.

Table 1. The Distribution of Pre-service Physics Teachers' Cognitive Structure related to the Concept of "Torque"

Categories	Concepts and Frequencies in Categories	Total Frequencies
Torque definition	Axis (3) Rotation effect (11) Moment (19) Force – Effort arm (18) Rotation (3)	54
Torque – Lesson Relationship	Physics (20) Difficult questions (7) Exam (5) Mechanics (4)	36
Direction of Torque	Direction (5) Right-hand rule (3) Balance (3)	11
Torque in Daily Life	Ferris wheel (5) Door handle (10) Pulley (3) Seesaw (3) Trolley (3) Nippers (3) Weighing machine (3)	30
Total	19 words	131 words

The pre-service physics teachers used five different concepts in the category of "Torque definition" 54 times in total. The concept most frequently used in this category was the concept of "moment"- which was followed by the concept of "Force – Effort arm". In the category of Torque-Lesson Relationship, four concepts were used in total. The concept most frequently used in this category was the concept of "Physics". Pre-service teachers set up direct associations between the concept and the lesson. Because the students had encountered the concept of Torque in mechanics course for the first time, some of them also associated the concept with the course. The pre-service physics teachers used three concepts in total in the category of "Direction of Torque". It was interesting that they associated the concept with the concepts of right hand rule and equilibrium, and it was an expected result. One of the most important findings was the findings in relation to the category of "Torque in Daily Life". In this category, prospective physics teachers set up

direct associations between the concept of torque and daily life and offered explanations. The most frequently used word was “door handle”. This might be because it was the most frequently given example in course books.

A model reflecting pre-service physics teachers’ cognitive structures about the concept of torque was created (see Figure 1). As is clear from the model, the pre-service teachers’ cognitive structures about the concept of torque are composed of the four categories distinguished with the analysis of WAT. An examination of Figure 1 shows that the category having the biggest number of concepts is the category of “Torque Definition”. Besides, it is also remarkable that there are scientific concepts in the concepts students use. In other words, it may be said that some students’ knowledge about the concept of torque is at comprehension level. The pre-service physics teachers explained the concept of torque by giving examples from daily life in the category of “Torque in Daily Life”. They explained the concept by using the incidents in their life and the materials they used in daily life as examples.

The majority of the students included in this category also made scientific sentences about torque. The following are some of the examples for their sentences:

St 14: *When force is applied to a substance fixed on a point, the substance rotates. This situation shows that force has rotating effect.*

St 21: *Thanks to the force we apply to the door handle, we open the door. This is an example for torque.*

St 8: *Car mechanics apply torque to screws while tightening screws, but they are not aware of this.*

On examining the examples above, we can say that the students’ words and examples about the concept of torque are scientific. That is to say, it may be stated that the students’ definitions about the concept of torque are operational definitions.

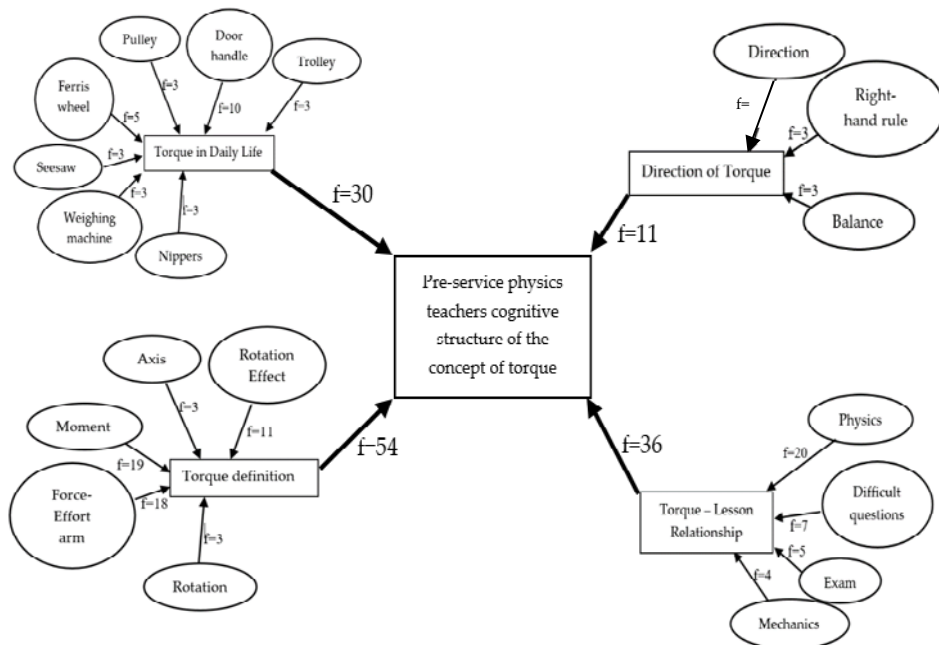


Fig. 1. The Model of Pre-Service Physics Teachers’ Cognitive Structures of Torque Concept.

Another property of WAT is that it determines students’ alternative conceptions and misconceptions. It was found in this study that pre-service physics teachers had some

alternative conceptions. Most important of them was that some of the pre-service teachers used the concepts of “torque” and “force” interchangeably. An example for this is given below:

St 5: In Mechanics course, the force we apply to a substance to rotate is called torque.

As in this example, a pre-service teacher states that torque- which arises in consequence of force- is identical with force. That is to say, the student means that force and torque are the same things. To exemplify this:

St29: Torque is the force of rotation.

In this example also the concepts of torque and force are used interchangeably. Pre-service teachers have not fully understood that there should be force in order for torque to occur. On the other hand, drawings made by pre-service teachers were found to be related with typical question samples available in course books. The fact that students’ drawings were restricted in scope in contrast to the categories indicated that they had superficial knowledge about the concept of torque. That is to say, it may be stated that variation in pre-service teachers’ cognitive structures about the concept is at minimum level. As supportive of this finding, it may be said that only 12 out of 32 pre-service teachers made drawings in addition to their answers to word association test.

4 Discussion and conclusion

The concept of Torque is one of the fundamental concepts included in mechanics course basically and in many physics subjects in general, and it is an important concept. In this context, teaching this concept will influence the teaching of other concepts connected with it. In other words, pre-service physics teachers’ having sound knowledge about the concept of torque will pave the way for complete understanding/learning in other subjects. This study distinguished four distinct categories about the concept of torque by using WAT. The categories were labelled as “Torque definition” (54), “Torque – Lesson Relationship” (36), “Direction of Torque” (11), and “Torque in Daily Life” (30) following content analysis. The examples pre-service physics teachers gave for the category of “Torque in Daily Life” were quite interesting. The category provides important information about structures arising in their minds about the concept of torque. In those examples given in relation to daily life, pre-service teachers heavily preferred actions in which there is the movement of “rotation”. Additionally, examples related with seesaw or simple machines (such as nippers, pulley, etc.) were also remarkable. Indeed, students’ use of scientific knowledge that they have learnt in daily life is an example indicating that complete learning has occurred. Yet, research has found that students have difficulty in setting up associations between what they have learnt in physical sciences and daily life or that they are inadequate in using scientific knowledge in appropriate scientific statements [13, 14, 15 and 16].

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